3023

Programmable Power Supply for Polyacrylamide Gel Electrophoresis

Polyacrylamide gel electrophoresis with a vertical slab was first applied to the analysis of casein by Peterson (1). Subsequently this method was adopted by many researchers either for the routine examination of casein or for judging the purity of isolated components of casein. Of course, polyacrylamide gel electrophoresis has been widely used to study other protein systems. The resistance of the polyacrylamide gel increases during electrophoresis. According to Peterson (2) this is due to the migration of ammonium persulfate (0.06 M) and of 3-dimethylaminopropionitrile (0.01 M) out of the gel, which is otherwise continuous with the external buffer, as well as with the sample solutions. Peterson (2) has found that gel solution without catalyst and initiator has a specific resistance three times greater than the solution used to cast a gel. During a typical run, then, the loss of catalyst and initiator current carriers permits a higher potential gradient to be applied to the gel without pattern distortion from excessive current flow. In addition, the current and potential gradient combination must not exceed the power limits set by the heat dissipation capacity of the cooling system of the Raymond cell (3). For these reasons, the voltage and current applied to the cell are usually varied during electrophoresis. Consequently, neither constant voltage nor constant current operation alone is feasible throughout an entire run.

In recent years power supplies with outputs controllable by external circuitry have become commercially available. Polyacrylamide gel electrophoresis according to Peterson (1) can be performed automatically, after the initial setup, by the programmed power supply described in this note. Such a power supply becomes most valuable whenever minimum attention is required for an electrophoresis run. Another good feature is the standardization and reproducibility of gel electrophoresis patterns brought about by fixed control of the voltage presented to the electrophoresis cell as a function of time. In addition, this programmable power supply could be used for other equipment, such as the preparative polyacrylamide gel electrophoresis apparatus of Duesberg and Rueckert (4).

A Kepco model HB2AM[1] was used as the power supply. The output

[1] Reference to a company or product name does not imply approval or recommendation of the product by the U. S. Department of Agriculture to the exclusion of others that may be suitable.

voltage can be controlled by a resistance, roughly equal to 100 ohms/V, placed in the control circuit between terminals #11 and #14 on the back of the instrument. Variable resistances (Trimpots) are placed into the control circuit by a Sealectoswitch, part no. 92-2066-212. This unit consists of a bank of 20 snap-action microswitches activated by tabs set in up to 60 rows on a drum that can revolve at 2 rpd. A schematic diagram is presented in Figure 1. As the drum of the Sealectoswitch rotates a series of 5000-ohm variable resistors are added to the control circuit resistance and the voltage to the cell is increased by discrete steps. In order to avoid synchronization problems, before a switch re-

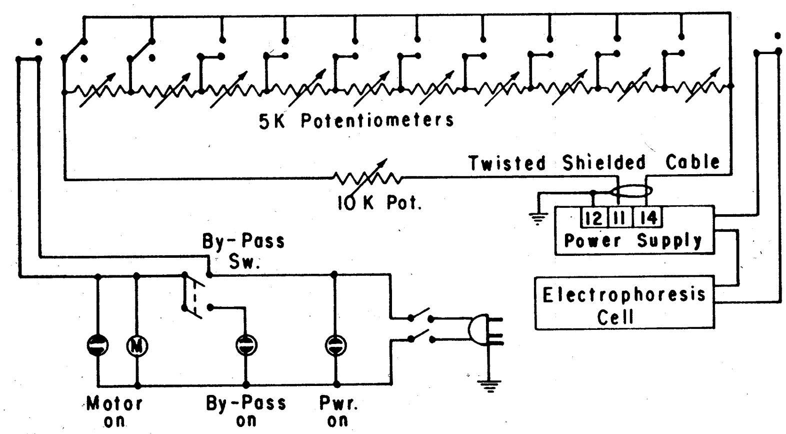

FIG. 1. Schematic diagram for programmed power supply. Boxed numbers refer to terminals at back of the Kepco model HB2AM power supply. Variable resistors are Bourns, Inc., Trimpots. The row of switches correspond to the bank of snap-action microswitches of a Sealectoswitch (Sealectro Corp.). Switches close from left to right as drum rotates.

leases the by-pass from the resistance to be put into the control circuit, a switch is closed to by-pass the next resistance to be used. A neon lamp monitors the state of the drum motor. For convenience, a flashing neon lamp is used to indicate that the drum motor by-pass switch is on. This switch is turned off some 15 min after the program is started in order to allow automatic shutdown at the end of the run. A program is set up by positioning tabs along rows of the Sealectoswitch drum. The rotating drum brings each tab into contact with a snap-action microswitch, which is activated during the 12 min period the tab remains in contact. Each switch can operate normally open or normally closed. Two 6 hr programs were set up on the drum to accommodate the 12 hr rotation period of the motor.

Figure 2 shows two identical gels from the electrophoresis of whole α_s-

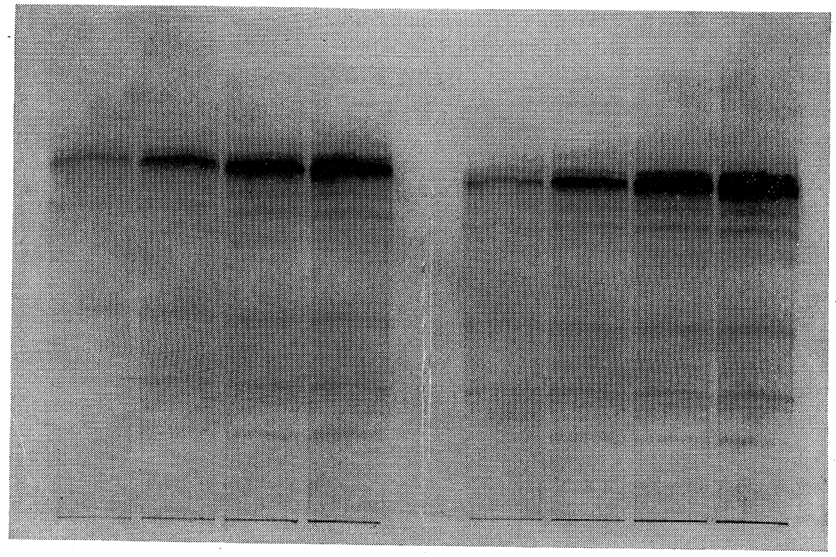

FIG. 2. Duplicate alkaline polyacrylamide gel electrophoresis patterns of whole α_s-casein. Tris(0.09 M)/EDTA(0.0035 M)/borate(0.0125 M) buffer at pH 9.2, 6.5% Cyanogum, 4.5 M urea. Protein concentration 1% (mercaptoethanol present); 10, 20, 30, and 40 μl amounts in slots from left to right. Cooling water temperature 11°.

casein, which was a gift of Dr. M. P. Thompson. The reproducibility of the electrophoresis is quite satisfactory. The voltage and current applied to the cell during one run is shown in Figure 3. After an initial run-in period at 100 to 150 V, the voltage was increased in steps such that the

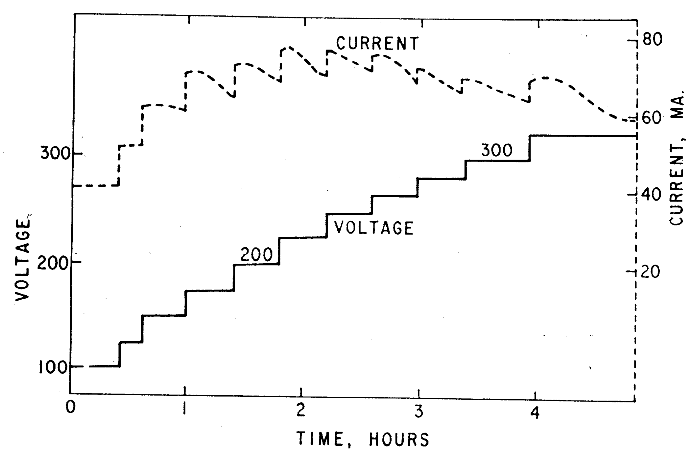

FIG. 3. Voltage and current curves for polyacrylamide gel electrophoresis patterns shown in Figure 2. Voltage steps occur at periods comprised of 12 min units.

current remained between 60 and 80 mA. The run was completed at 325 V. Following each voltage jump the current rose accordingly, held constant or increased slightly for a few minutes, and then decreased sharply. Thus, the response of the gel to the applied voltage was not simple and probably reflects a readjustment of the distribution of current carriers to the greater potential gradient.

Several variations are possible with the equipment described in this note. Fewer or more variable resistors can be incorporated into the control circuit. The voltage steps can be set to any desired levels and the times can be lengthened or shortened by 12 min intervals. Constant current operation can be obtained by circuit revision.

The programmed power supply, to conclude, has proved to be a very useful device for polyacrylamide gel electrophoresis and has provided rigorous control of routine work.

ACKNOWLEDGMENTS

I wish to thank Mr. Joseph A. Connelly and Dr. Robert F. Peterson for helpful discussions.

REFERENCES

1. Peterson, R. F., *J. Dairy Sci.* **46**, 1136 (1963).
2. Peterson, R. F., personal communication (1968).
3. Raymond, S., and Nakamichi, M., *Anal. Biochem.* **3**, 23 (1962).
4. Duesberg, P. H., and Rueckert, R. R., *Anal. Biochem.* **11**, 342 (1965).

Peter D. Hoagland

Eastern Utilization Research and Development Division
Agricultural Research Service
U. S. Department of Agriculture
Philadelphia, Pennsylvania 19118

Received May 3, 1968